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AUTHOR Hendrix, Vernon L.; Sederberg, Charles H.
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ABSTRACT

Minnesota's attempt to equalize school spending through state payments to low-expenditure districts succeeded only partially in reducing statewide variation in districts' per-pupil expenditures. To test the effects of the state's 1973 law, and to test a new statistical technique for simultaneous assessment of variability in many factors, researchers gathered data on size in 1973, wealth in 1970, per-pupil expenditures in 1973 and 1979, and enrollment trends from 1973 to 1979 for each of 432 Minnesota school districts. Variability in expenditures was measured by the size of the standard deviation from the statewide mean. Data analysis using the new technique showed that variation in per-pupil expenditures across all districts fell 13 percent from 1973 to 1979. The largest reduction in variability occurred among small, low-wealth districts, especially those with declining enrollments. The smallest variability reduction took place in large, high-wealth districts. (RW)

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CORRELATES OF CHANGE IN PUPIL
UNIT EXPENDITURE VARIABILITY

by

Dr. Vernon L. Hendrix

and

Dr. Charles H. Sederberg

Center for Educational Policy Studies

College of Education

University of Minnesota

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Dr. Vernon L. Hendrix
Dr. Charles H. Sederberg
University of Minnesota

Background of the Study

The purposes of the study were to (1) assess change in variability of pupil unit expenditure across a six-year period and (2) explore the utility of a technique for analysis of dispersion statistics suggested by the work of Toothaker, Hicks, and Price.¹ Interest in pupil unit expenditure variability was stimulated by a statutory revenue "catch-up" provision aimed at equalizing pupil unit expenditures. Minnesota Statute 124.122 provided that during the six-year period from fiscal years 1973 through 1979 all Minnesota school districts spending less than the state average of \$663 during the fiscal 1971 base year would be provided with additional foundation revenue to raise average pupil unit expenditures to the state average. Districts spending above the average in fiscal year 1971 were not affected by the "catch-up" provision. Passage of the statute implied acceptance of comparability of adjusted maintenance expenditure per weighted pupil unit (kindergarten = .5, grade 1-6 = 1.0 and grades 7-12 = 1.4) as a criterion of educational equity.

¹Larry Toothaker, J. Hicks, and J. Price. "Optimum Subsample Sizes for the Bartlett-Kendall Homogeneity of Variance Test," Journal of American Statistical Association Vol. 73 #361, March, 1978, pp. 53-57.

The "catch-up" provision represented only one element of a complex grades K-12 foundation revenue formula. Resources were not available to collect data which would permit partialing out its effect relative to other formula elements such as a "grandfather" excess cost levy, AFDC concentration aid, etc. However, if the policy intent of the statute were achieved, one would expect variability of pupil unit expenditures to decrease across the implementation period. Furthermore, if changes in variability did occur, research interest included relationships to independent variables of size, wealth, and enrollment trends. The following research questions associated with the first purpose of the study emerged from these background circumstances:

1. *To what extent did variability in pupil unit expenditures among districts change during the fiscal years 1973-1979 implementation period of the M.S. 124.122 revenue "catch-up" provision?*
2. *How were the variables of size (1973 enrollment), wealth (1970 district adjusted assessed valuation) and enrollment trend (average annual percent change from 1973 to 1979) related to change in variability of adjusted maintenance expenditure per weighted pupil unit in average daily membership?*

Interests in study methodology stemmed from limitations in traditional methods for comparing variances. Use of F-ratios allows comparison of only two variances. The Barlett homogeneity of variance method permits comparing any number of variances but only in a one-way analysis mode. Toothaker, Hicks, and Price explored a Monte Carlo technique in which random samples without replacements were taken from sets of scores. A variance was computed for each sample and the natural log of each sample variance was determined. These natural logs were then treated as "scores" in an

analysis of variance to see if differences in population variances could be detected. Establishment of a design matrix by authors of the present study permitted asking questions about one predictor variable in the presence of other variables and about interactions among predictor variables. The following research question associated with the second purpose of the study emerged from these methodological considerations:

3. *Is a design matrix approach following the work of Toothaker, Hicks, and Price a workable and useful method for addressing research questions no. 1 and no. 2?*

Study design, results, and conclusions are presented in the following sections.

Study Design

Design of the study is reported in the following sections dealing with population, sources of data, and treatment of data.

Population

The population consisted of all K-12 school districts in the State of Minnesota in the FY 1973 that did not undergo any type of organizational change (consolidation, annexation, etc.) before the end of the FY 1979 (N=432). No sample was drawn because data allowing assessment of the entire population were available.

Sources of Data

The following data were obtained from printed reports or computer tapes prepared by the Minnesota State Department of Education:

1. District average adjusted maintenance expenditure per weighted pupil unit in average daily membership (WPU/ADM) for fiscal years 1973 and 1979.
2. Total October enrollments (K-12) for FY 1973 and FY 1979 to be used (a) as a measure of district size (FY 1973) and (b) to compute the average annual percent of change in enrollment between FY 1973 and FY 1979.
3. District wealth, as measured by district 1970 adjusted assessed valuation.

Consumer Price Index data were obtained from U.S. Department of Commerce publications.

Treatment of Data

Criterion variables for this study consisted of adjusted maintenance expenditure per WPU/ADM for each of the two selected years. Expenditure levels for FY 1979 were equated to FY 1973 expenditures by using the Consumer Price Indices for the two time periods. All dollar amounts in the report are expressed in terms of constant 1973 dollars.

Total enrollment for each district in FY 1973 was used as a measure of district size. For purposes of analysis, size was dichotomized at the median. Small districts consisted of those with enrollments equal to or less than 838. Large districts consisted of those with enrollments of 839 or larger.

For each district, a measure of wealth was calculated by dividing the 1970 adjusted assessed valuation by the total October enrollment in FY 1973 to yield an adjusted assessed valuation per student enrolled. For purposes of analysis, the wealth variable was also dichotomized at

the median, resulting in low wealth districts having \$10,100 or less in adjusted assessed valuation per student and high wealth districts having over \$10,100 assessed valuation per enrolled student.

Enrollment trend was calculated by subtracting the total enrollment in FY 1973 from the total enrollment in FY 1979 and dividing by the FY 1973 enrollment. This proportion was multiplied by 100 to convert to a percent of change and divided by six, to yield an average annual percent of change. The median change in enrollment per year over the six year time span was a negative 1.5 percent. For purposes of analysis, this enrollment trend variable was also dichotomized at the median. Negative enrollment trend districts thus decreased on the average 1.5 percent or more each year over the six year time span. Stable or positive enrollment trend districts decreased at less than 1.5 percent per year or even increased.

Since the primary questions dealt with in this study pertained to changes in variability, an appropriate descriptive statistic was the standard deviation of adjusted maintenance expenditure per WPU/ADM for each of the two years. Because the study was able to consider the entire population of districts, there were no statistical inference problems. Therefore, the descriptive statistics could be examined and related directly to the study questions. However, in order to permit a more explanatory assessment of the relative strength of the independent variables and in order to see how specifically the data corresponded to the given model implied in the questions, a multivariate repeated measures analysis of variance was conducted. This analysis used the MANOVA sub-program of the SPSS system at the University of Minnesota Computing Center. The repeated measures were adjusted maintenance expenditures per WPU/ADM for fiscal years 1973 and 1979. The design variables were wealth, size,

and enrollment trend resulting in an eight-cell pattern on the design variables with two criterion values in each cell.

Since the criterion variables were themselves measures of variability rather than point estimates, a technique was first utilized to linearize the variability measures. This was done by using a technique suggested by Toothaker, Hicks and Price and described in the background section of this paper.

From one point of view, statistical inference was not a concern in this study since the entire population was available. However, from another point of view (related to random changes over time), there could have been an undetermined sampling error present. The suggestions based on the Monte Carlo studies conducted by Toothaker and others to control for Type II error and maximize power were followed. Therefore, the sample variances were selected three different ways, based on sample sizes of three, four, and five.

Results of the Study

The first study question was, "To what extent did variability in pupil unit expenditures among districts change during the fiscal year 1973-79 implementation period of the M.S. 124.122 revenue 'catch-up' provision?" The principal descriptive statistics (standard deviations), stratification variables (wealth, size, and enrollment trend), and frequency of districts in each cell of the stratification design are presented in Table 1. Data in Table 1 (E) indicated that the standard deviation for adjusted maintenance expenditures per WPU/ADM in FY 1973 was \$107.18. With expenditures per WPU/ADM in FY 1979 equated to FY 1973 dollars using the Consumer Price Index, the standard deviation was \$92.85, indicating a 13.4 percent reduction in variability across all districts in the state.

Table 1

Population Stratifications, Frequencies and Standard Deviations -
Adjusted Maintenance Expenditures per WPU/ADM

(A) Wealth x Size x Enrollment Trend

		Wealth			
		Low		High	
		Size		Size	
Enrollment Trend		Small	Large	Small	Large
Negative	σ 1973	127.46	89.26	102.01	119.83
	Decrease	39.83	10.01	-1.92	25.30
	σ 1979	87.63	79.25	103.93	94.53
	N	22	44	92	58
Stable & Positive	σ 1973	86.75	97.84	94.09	90.71
	Decrease	11.38	9.93	12.72	16.57
	σ 1979	75.37	87.91	81.34	74.14
	N	61	91	41	23

(B) Wealth x Size

		Wealth	
		Low	High
Size	Large		
	σ 1973	99.99	99.32
	Decrease	21.59	1.08
	σ 1979	78.40	98.24
Small	N	83	133
	σ 1973	100.07	112.04
	Decrease	10.89	21.41
	σ 1979	89.18	90.63
Small	N	135	81

(C) Wealth x Enrollment Trend

		Wealth	
		Low	High
Enrollment Trend	Negative	σ 1973 Decrease σ 1979 N	103.38 21.24 82.14 66 150
	Stable & Positive	σ 1973 Decrease σ 1979 N	109.25 8.85 100.40 152 64

(D) Size x Enrollment Trend

		Size	
		Small	Large
Enrollment Trend	Negative	σ 1973 Decrease σ 1979 N	107.39 6.44 100.99 114 102
	Stable & Positive	σ 1973 Decrease σ 1979 N	107.71 19.45 88.26 114 102

(E) Marginals

		σ 1973	Decrease	σ 1979	N
Wealth	Low	99.94	14.63	85.31	218
	High	105.29	9.25	96.04	214
Size	Small	99.46	8.67	90.79	216
	Large	101.92	15.20	86.72	216
Enrollment Trend	Negative	107.54	12.35	95.19	216
	Stable & Positive	93.35	11.49	81.86	216
Total		107.18	14.33	92.85	432

The second study question was, "How were the variables of size (1973 enrollment), wealth (1970 adjusted assessed valuation) and enrollment trend (average annual percent change from 1973 through 1979) related to change in variability of adjusted maintenance expenditures per weighted pupil unit in average daily membership?" To ascertain the answer to this question, a general linear model permitting the assessment of the effect of each design variable (wealth, size, and enrollment trend), all possible two way interactions, and the three way interaction was chosen. This repeated measure multivariate analysis of variance was conducted on linearized sample variances (as described in a preceding section) based on samples of three, four, and five. The results of these three analyses were summarized in Table 2. Table 2 information was not necessary for statistical inference, however, it was used as a guideline for describing the nature of the relationships which existed between wealth, size, and enrollment trend and the variable of primary research interest which was change in variability of expenditures.

An arbitrary decision rule for evaluating the parameters in Table 1 was; if any of the three analyses reported in Table 2 resulted in a probability of .5 or less for any of the effects, it was considered worthy of discussion.

Wealth

Based on Table 2, wealth may be considered to be related to the amount of decrease in variability. Examination of Table 1 (E) indicated that a greater decrease in variability occurred for low wealth districts than for high wealth districts. This was true, even though low wealth districts had slightly lower variability in FY 1973 than high wealth districts.

Table 2

Multivariate Repeated Measure Analysis of
Variance on Linearized Sample Variances
Based on Sample Sizes of 3, 4 and 5

Effect	N=3		N=4		N=5	
	F df=1/133	P	F df=1/98	P	F df=1/76	P
W x S x T	1.06 (-)*	.30	3.29 (-)	.07	.24 (-)	.62
S x T	.02 (+)	.90	.13 (+)	.72	.48 (+)	.49
W x T	.36 (-)	.55	.05 (+)	.83	1.34 (-)	.25
W x S	.53 (-)	.47	1.41 (-)	.24	.83 (-)	.36
T	.12 (-)	.73	.08 (-)	.77	.42 (+)	.52
S	1.78 (+)	.18	3.41 (+)	.07	4.09 (+)	.05
W	1.04 (-)	.31	1.40 (-)	.24	3.99 (-)	.05

*These signs are abbreviations for the pattern of interaction and were derived from the signs of the coefficients of the appropriate vector in the design matrix.

Size

Data in Table 2 indicate that size was rather strongly related to the amount of change in variability. Examination of Table 1 (E) indicated that the variability for small districts decreased by about half of that for large districts. The variability for small districts and large districts differed very little in the starting year (1973).

Enrollment Trend

Based on Table 2 data and the previously stated decision rule, enrollment trend did not appear to be related to change in variability. Examination of Table 1 (E) indicated that although negative enrollment trend districts had much higher variability in FY 1973 than stable or positive enrollment trend districts, the amount of change in variability by FY 1979 differed less than one dollar.

Wealth by Size

Based upon the decision rule and the data in Table 2, there appeared to be an interaction between wealth and size as related to change in variability. As indicated in Table 1 (E), low wealth districts decreased in variability more than high wealth districts and large districts decreased in variability more than small districts. Examination of the parameters in Table 1 (B) indicates, however, that there was practically no change for high wealth large districts and a great deal of change for large low wealth districts and small high wealth districts. The generally greater decline in variability for low wealth districts was accelerated for large districts (\$21.59). This decrease in variability for low wealth districts appeared to be slowed down for small districts. In other words, the generally greater decrease in variability for large districts is accelerated for low wealth districts and

almost disappears for high wealth districts. The decrease for small districts appeared to be accelerated in high wealth districts. Variability for high wealth large districts changed approximately one dollar. The greatest decrease in variability occurred for large low wealth districts and small high wealth districts; the change approximated \$22.

Wealth by Enrollment Trend

Examination of Table 2 indicated that one of the tests (based on a sample size of 5) produced a probability of less than .5. However, it was also found that the actual results of these tests indicated differing types of interactions. Therefore, this was not considered to be a sufficiently strong interaction for extensive discussion. If a wealth by enrollment trend interaction should be considered, examination of Table 1 (C) indicated that the negative relationship between wealth and decrease in variability became almost nonexistent--even slightly positive--for stable and positive enrollment trend districts as opposed to negative enrollment trend districts.

Size by Enrollment Trend

Table 2, given the decision rule, indicated that a size by enrollment trend interaction should be considered. Examination of Table 1 (D) indicated that the positive relationship between size and decrease in variability existed primarily for negative enrollment trend districts and was almost nonexistent for stable and positive enrollment trend districts.

Three Way Interaction

Examination of Table 2 indicated that a three way interaction among wealth, size, and enrollment trend should be considered. Examination of Table 1 (A) and Table 1 (B) indicated that enrollment trend may be considered

as mediating the interaction between wealth and size. The positive relationship between wealth and the WPU/ADM expenditure variability decrease for small districts and the negative relationship between wealth and the WPU/ADM expenditure variability decrease for large districts became even more pronounced for negative enrollment trend districts. Wealthy large districts with negative enrollment trends showed a decrease in variability of \$25.30. Small, low wealth districts with negative enrollment trends showed a decrease of \$39.83 in variability, the largest decrease of any single type in the stratification design.

The third study question was, "Is a design matrix approach following the work of Toothaker, Hicks, and Price a workable and useful method for addressing research questions no. 1 and no. 2?"

While the technique employed was not absolutely essential because of availability of population data, it did prove to be a workable and useful method. The method was deemed useful because it permitted an assessment of interactions and facilitated explanation of the results.

Conclusions and Implications

Based on the data collected and study procedures applied, the following conclusions were drawn:

1. Variability in adjusted maintenance expenditure per weighted pupil unit in average daily membership decreased 13.4 percent from \$107.18 to \$92.85, in terms of constant dollars adjusted by the Consumer Price Index, across all districts in the state during the six year implementation period of the foundation revenue "catch-up" provision (M.S. 124.122) from Fiscal Years 1973 through 1979.

2. Achievement of the policy goal of equalizing pupil unit maintenance expenditure (reducing variability) tended to be realized more among low wealth

and small enrollment size districts with little relationship to enrollment trend. Two-way interaction analyses indicated that there was practically no change for large, high wealth districts, but variability was reduced considerably among large, low wealth districts and among small, high wealth districts. Three-way interaction of wealth, enrollment size, and enrollment trend indicated that enrollment trend tends to mediate the interaction between wealth and size. The positive relationship between wealth and decrease in expenditure variability in small districts and the negative relationship between wealth and decrease in expenditure variability for large districts is more pronounced for districts with declining enrollment.

3. Analysis of change in variances of adjusted maintenance expenditure per pupil unit in average daily membership for a population of districts can be facilitated by the design matrix technique derived from the work of Toothaker, Hicks, and Price, if expenditures are adjusted to constant dollar values using an appropriate index. If a sample of districts were involved, the design matrix technique would be essential for testing statistical hypotheses.

The results of the study imply that the legislative policy intent of M.S. 124.122 to equalize adjusted maintenance expenditure per pupil unit was achieved to a limited extent among all districts in the state across the implementation period. Limitations of the study did not permit isolation of the magnitude of the effect specifically attributable to the "catch-up" provision relative to other components of the foundation formula. However, the reduction in variability indicated a trend in the desired direction. The expenditure equalization or variability reduction effect did not have the same impact on all districts. The greatest reduction in variability occurred among small, low wealth districts with declining

enrollment. This finding is intuitively logical because districts having these characteristics are the ones most likely to fall in the low spending category addressed by the statute. Further study would be justified for (1) application of the procedure to low spending districts and high spending districts separately and (2) analysis which would partial out the effects of the "catch-up" provision compared to other elements of the foundation aid formula.